#432

PIONEER 11

DOPPLER TRACKING DATA

73-019A-09A

PIONEER 11

DOPPLER TRACKING (JUPITER ENCNTR)

73-019A-09A

This data set has been restored. There was originally one 7-track, 800 BPI tape written in Binary. There is one restored tape. The DR tape is a 3480 cartridge and the DS tape is 9-track, 6250 BPI. The original tape was created on a 1108 computer and the restored tape was created on an IBM 9021 computer. The DR and DS numbers along with the corresponding D number are as follows:

DR#	DS#	D#	FILES	TIME SPAN
DR005639	DS005639	D023989	1	04/17/74 - 12/25/74

PIONEER 11

DOPPLER TRACKING DATA

73-019A-09A

This data set contains one Pioneer 11 doppler tracking data tape. The data were created on a UNIVAC 1108 using FORTRAN IV unformatted write statements, and are 800 BPI, binary, 7 track, with one file of data. The tape consists of a series of records, divided into groups, which describe the tape itself, or contain actual satellite data. The tape begins with a File Identification Group, followed by a User Label Group, a Ramped Transmitter Group (described in Appendix A of format), and Orbit Data Summary Group, an Orbit Data Identifier Group, an Orbit Data Group (which contains the actual satellite orbit data), a Control Statement Group, and a Close File Group. All records are written in logical records of 28 (36-bit) words except for the Orbit Data Group records which are 252 words each.

The time span for the data is as follows:

D#	C#	TIME SPAN
D-23989	C-20767	4/17/74 - 12/25/74

Spacecraft Common Name:

Pioneer ll

NSSDC ID 73- 019A - 09A

Originator _____ Date / /

Agent Assigned _____ Date 8/4/76

Sys. Coord. _____ Date / /

☐ Brief Description ☐ New ☐ Add/Replace
Date Last Updated: _____

☑ Materials for Distribution

☐ Remarks

☐ Accession Units

☐ Objectives

☐ Full Description

☐ Performance Summary

☐ Potential Scientific Uses of Data

☐ Data Set Quality

☐ Master Data Record Release Summary

(Note: Indicate new, add, replace, delete existing data, and/or other appropriate
instructions for each free text field that follows, except brief description.)

Material to be sent includes copiex of a letter (dated July 14, 1976,

from G. Null to C. Wende), a description of the tape format, a copy of

TR 32-1527 ('Mathematical Formulatinn of the Double-Precision

Orbit Determination Program (DPODP))', JPL Tech. Memorandum 391-412,

a copy of an article from Science (vol. 188, no. 4187, entitled

'Pioneer 10 and 11), a copy of a paper entitled 'The Gravity Field of

Jupiter and its Satellites from Pioneer 10 and 11 Tracking Data'),

and copies of a lsit of tracking statimn locations, initial trajecgory

conditions, and a partial listing of the tape contents (all grouped under

TRF B).

24488

14 July 1976

Mr. Chuck Wende
National Space Science Data Center
Code 601.1
Goddard Space Flight Center
Greenbelt, Maryland 20771

Dear Mr. Wende:

This is to notify you that I have mailed a magnetic tape containing Pioneer 11 Doppler tracking data to you at the National Space Science Data Center (NSSDC). These data, which cover the period 15 October - 28 December, 1974 were taken near Jupiter and used by the Pioneer 10/11 celestial mechanics experiments, Dr. J. D. Anderson of JPL and myself. The tape you will receive (tape 40) was written at JPL on a Univac 1108 computer in the standard 7 track, BPI Fortran mode with 36 bit word length. Please send a replacement to me at the address given above.

The following explanatory materials are enclosed:

1. A description of the data tape format. Some of the doppler tracking data were taken while the ground transmitter frequency was changing at a precisely controlled linear rate. A list of the times at which these data were taken is given in the following table. The necessary information about the ramped transmitter frequency is given in the ramped transmitter groups on the tracking data tape. These groups are defined in appendix A of the tracking format description.

PIONEER 11 RAMP PASSES

DATE	STA	Approx. Ground Transmit Time (U.T.C)	Approx. Ground Receiver Interval
22 Oct. '74	14	0500 - 0520	0430 - 0730
27 Oct. '74	14	0600 - 0620	0530 - 0830
3 Nov. '74[*]	14	0400 - 0420	0330 - 0630
7 Nov. '74	14	0100 - 0170	0030 - 0330
13 Nov. '74[*]	43	0730 - 0750	0700 - 1000
21 Nov. '74	14	0100 - 0120	0030 - 0330
25 Nov. '74	43	0800 - 0820	0730 - 1030

1 Dec. '74	14	0150 - 0210	0120 - 0420
3 Dec. '74	14	0401 - 0427	0400 - 0627
10 Dec. '74*	43	0530 - 0550	0500 - 0800
15 Dec. '74	43	0530 - 0550	0500 - 0800

*3 Nov., 13 Nov., 10 Dec., Ramped Intervals had bad data (round
trip signal delay was about 80 minutes)

2. On copy of TR 32-1527 defining the standard S-band, two-way observable
found on the data tape. See pages 19-22, 46-50, 72-75. The observables on
both the Pioneer 10 and Pioneer 11 data tapes were adjusted for the effect
of spacecraft spin on the observable and the revised values substituted
for the original ones. The correction (Δf) added to the S-band Doppler
observables was computed from

$$\Delta f = \omega(.034766213) \text{ Hertz}$$

where ω is the spacecraft spin rate in revolutions per minute. This correc-
tion follows from the fact that the Pioneer 10 antenna is rotating and right
hand circularly polarized; the correction was verified by ground tests and
with the spacecraft themselves. The Pioneer 10 corrections for 15 October -
28 December '73 were in the range .16531 Hz to .16525 Hz. The Pioneer 11
corrections for 15 October - 26 December, '74 were in the range .17558 Hz to
.17542 Hz.

Doppler biases of the size shown have a negligible effect on the Jupiter
gravity solution provided that either a constant Doppler bias or a conic
planetary ephemeris correction is included in the solution. The use of the
wrong value of the bias would produce an erroneous range rate correction
to the planetary ephemeris, however.

3. One copy of TM 391-412 by T. D. Moyer giving the necessary equations for
computing ramped Doppler.

4. A reprint of a Pioneer 11 journal article giving the preliminary results
of the Pioneer 11 Celestial Mechanics Experiment (pp. 1-2, 476-477), and a
preprint of results from the Pioneer 10 and 11 combined analysis (submitted
to the Astronomical Journal, July, 1976).

5. A list of Deep Space Net Tracking station locations.

6. Trajectory coordinates sufficient to start a least squares adjustment.

7. A listing of the beginning records of tape X440.

The Pioneer 11 spacecraft was perturbed by orientation maneuvers at the following times (UTC)

$$17 \text{ October } 74 \quad 17^h$$
$$6 \text{ December } 74 \quad 16^h$$
$$20 \text{ December } 74 \quad 16^h$$
$$3 \text{ January } 74 \quad 3^h.$$

The velocity perturbations were almost entirely along the earth line with a magnitude of less than 0.5 mm/sec. The tracking data provided is S-band, two-way Doppler data. Each data record contains both the observed Doppler (F) and the transmitter frequency (f_q) as defined in item (2).

Please instruct any potential users of the data to contact me if any questions arise concerning its use. Information concerning the Pioneer 10 solar radiation pressure can be obtained upon request to me; the memos describing this effect were too lengthy and complicated to include in this mailing. The effect of solar pressure on the Pioneer 10 and 11 spacecraft (primarily from the parabolic antenna and RTG's) can be approximated for the 15 October - 28 December period by an acceleration in the sun-spacecraft direction given by

$$\ddot{r}_R = k/r^2 \text{ where } \ddot{r} \text{ is in km/sec}^2,$$

$$r = \text{sun - spacecraft distance in km}$$

and

$$k = 3.89 \times 10^6 \text{ km}^3/\text{sec}^2.$$

This approximation has an error less than 10^{-13} km/sec^2. In addition there is an acceleration $(\ddot{r}_n)$ of .6 $\times$ 10^{-12} km/sec^2 normal to the sun-spacecraft line and located in the sun-spacecraft-earth plane. This acceleration is in the same half plane (divided by sun-spacecraft line) as the Earth.

The following table shows the actual solar pressure accelerations r_R and r_n for the full solar pressure model and the inferred value of K.

Date	Earth-spacecraft sun-angle	$\ddot{r}_R \times 10^{12}$	$K \times 10^{-6}$	$\ddot{r}_n \times 10^{12}$
18 Oct 74	8.4°	7.758	3.938	.49
3 Dec 74	11.4°	7.019	3.882	.61
22 Dec 74	11.1°	7.323	3.888	.62

The maximum earth-spacecraft sun angle for the encounter period was 11.49 degrees on 28 November, 1974.

Mr. Chuck Wende   4   14 July 1976

Sincerely yours,

George W. Null

George W. Null
Member of Technical Staff
Tracking & Orbit Determination
(213) 354-2052

GWN:ii

enclosures

SECTION IX

OD FILE LOGICAL RECORD FORMAT

GROUP RECORD WORD TYPE CONTENT

9.1   FILE IDENTIFICATION GROUP

9.1.1   Header Record

I	I	11	Size (in integer words) of each logical record in para 9.1.2
2	I	4	Identifies content of 9.1.2 records as BCD.
3	I	1	Indicates group does not end with a trailer record.
4	I	101	File id. group indicator
5	I	0	Not used

9.1.2   One Record Which Identifies the File

I	I	10	The number of integral words in the record.
2-4	BCD		"SPACECRAFT ID=xx "where xx is the spacecraft number input by the user in the OD-FILE statement.
5-9	BCD		"Y,M,D,H,M=xx,xx,xx,xx,xx ,1108" where the x's represent the time the file was written.
10-11	BCD		" ODE=xxxxxx" where x denotes the version of ODE that created the file.

9.2   USER LABEL GROUP

9.2.1   Header Record

1	I	15	Size (in integer words) of each logical record in para. 9.2.2
2	I	4	Identifies content of 9.2.2 records as BCD
3	I	0	Indicates group ends with a trailer

| 4 | I | 103 | Label group indicator |
| 5 | I | 0 | Not used |

9.2.2 Zero or More Records of BCD Descriptive Test

These would be input to the ODE by the user via the OD-FILE statement. The text would include any comments the user would have concerning the circumstances under which the file was created.

| 1 | I | 14 | The number of integral words in the record. |
| 2-15 | BCD | 84 | BCD characters taken from the LABEL parameter of the OD-FILE statement |

9.2.3 Group Trailer

| 1 | I | 1 | |
| 2 | BCD | Six BCD zeros | |

9.3 ORBIT DATA SUMMARY GROUP

9.3.1 Header Record

1	I	9	Size (in integer words) of each logical record in para. 9.3.2
2	I	2	Identifies content of 9.3.2 records as DPFP
3	I	0	Indicates group ends with a trailer
4	I	105	Orbit data summary group indicator
5	I	0	Not used

9.3.2 A Record For Each Data-Type that Exists for Each Station/Band

| 1 | I | 4 | Number of DPFP words in the record |
| 2,3 | DPFP | 1.0000000bc00eeffD+16 | |

where

b = radio band indicator (See Orbit Data Group)

c = tracking network indicator (See Orbit Data Group)

ee = receiving station number

ff = data-type indicator (See Orbit Data Group)

4,5	DPFP	Number of points
6,7	DPFP	Time of earliest point
8,9	DPFP	Time of latest point

Seconds after January 1, 1950, 0:0:0.0

9.3.3 Group Trailer

| 1 | I | 1 |
| 2 | DPFP | 0.0D+0 |

9.4 ORBIT DATA IDENTIFIER GROUP

9.4.1 Header Record

1	I	6	Size (in integer words) of each logical record in para 9.4.2
2	I	4	Identifies content of 9.4.2 records as BCD.
3	I	1	Indicates group does not end with a trailer record.
4	I	107	Orbit data identifier group indicator
5	I	0	Not used

9.4.2 One Record which Identifies the Various Fields and Their Positions Within the Orbit Data Record

| 1 | I | 5 | Number of integral words in the record. |
| 2-6 | BCD | | (TIMTAG, IDWORD, OBSVBL, FREQCY, PASSID). |

9.5 ORBIT DATA GROUP

9.5.1 Header Record

1	I	241	Size (in integer words) of largest logical record in 9.5.2.
2	I	2	Identifies content of 9.5.2 records as DPFP.
3	I	0	Indicates group ends with a trailer
4	I	109	Orbit data group indicator
5	I	0	Not used

9.5.2 A Series of Records (possibly void):

1	I	M	The number of double precision words of data in the record. M=120 except possibly for the last record in which M=R*5 where R is the number of logical records within the record.
2 to 2M+1	I	M/5 logical records	A logical record is as defined below

Orbit Data Logical Record

Words	Mode	Contents
1,2	DPFP	Time of observation; seconds after January 1, 1950 0:0:0.0
3,4	DPFP	1.aaaaaaabcddeeffD+16

where

aaaaaaa	=	doppler compression time in hundredths of seconds for doppler data
	=	0 for DRVID
	=	ranging components for range data
	=	0 for angle data

615-124

b	=	radio band indicator. 1 = S, 2 = X, 3 = L, 4 = LS
c	=	tracking network indicator. 1 = DSN, MSFN, 3 = ETR
dd	=	transmitting station number
ee	=	receiving station number
ff	=	data-type indicator

11 = one-way doppler (F1)

12 = two-way doppler (F2)

13 = three-way doppler (F3)

14 = three-way coherent doppler (F3C)

24 = DRVID using TAU ranging (DTAU)

25 = DRVID using MU ranging (DMU)

26 = DRVID using PLOP ranging (DPLOP)

27 = DRVID using PLOP2 ranging (DPLOP2)

28 = DRVID using MU2 ranging (DMU2)

31 = ETR range (ETR)

32 = MARK 1 range (MARK1)

33 = MARK1A range (MARK1A)

34 = Tau range (TAU)

35 = Mu range (MU)

36 = planetary operational discrete spectrum (PLOP)

37 = planetary operational continuous spectrum (PLOP2)

38 = planetary R&D (MU2)

51 = azimuth (AZ)

52 = elevation (EL)

53 = hour angle (HA)

54 = declination (DEC)

55 = X30 (X30)

$$56 = Y30\ (Y30)$$
$$57 = X85\ (X85)$$
$$58 = Y85\ (Y85)$$

5,6   DPFP   One of the following

    i)   doppler observable

    ii)   DRVID observable

    iii)   range observable

    iv)   angle observable

7,8   DPFP   Reference frequency for doppler, DRVID and range data, 0 for angle data, where **reference frequency is** defined as the frequency of the

    i)   <u>Transponder</u> if doppler ground mode is one-way

    ii)   <u>Transmitter</u> if doppler ground mode is two-way, three-way, or three-way coherent. Reference frequency is taken at light **corrected time of** data point.

9,10 DPFP   1.aaaabD+16

where

aaaa = Pass identification

b   = Split pass identification

The logical data records are ordered in increasing order of time/net/station/data type/band.

9.5.3   Group Trailer

    1   I   1

    2,3   DPFD 0.0D+0

9.6   CONTROL STATEMENT GROUP

9.6.1   Header Record

    1   I   15   Size (in integer words) of each logical record in para. 9.6.2

2	I	4	Identifies content of 9.6.2 records as BCD
3	I	0	Indicates group ends with a trailer
4	I	111	ODE control statement group indicator
5	I	0	Not used

9.6.2   BCD Card/Line Images of All the ODE Control Statements

.1	I	14	The number of integral words in a record
2-15	BCD		14 words of card/line imate (84 BCD characters)

9.6.3   Group Trailer

1	I	1
2	BCD	Six BCD zeros

9.7   FILE CLOSE GROUP

9.7.1   Header Record

1	I	1
2	I	5
3	I	0
4	I	0
5	I	0

9.7.2   End of File Mark

The entire OD file is written and read with non-formatted (binary) read and write FORTRAN V statements. The data within each record are ordered and typed as specified above; the various file groups are also ordered as shown in paragraphs 9.1 through 9.7.

APPENDIX A

Format of the Ramped Transmitter Groups on
the Type 66 ODE Tracking Data File

The ramped transmitter groups shall appear on the ODE data file between the User Label Group and the Orbit Data Summary Group. There shall be one Ramped Transmitter Group for each station for which ramped transmitter information was supplied to ODE. Each of these groups shall have the format

1. Header
   Word

1	I	129	Maximum size (in S.P. words) of each data record
2	I	2	Identifies data records as double precision
3	I	0	Indicates group ends with a trailer record
4	I	2030	Key 1
5	I	DSN Station Number	Key 2

A group with Key1 = 2030, Key2 = 0 can be ignored

2. Data records

Each data record shall consist of an integer NWORDS plus up to 16 packed transmitter messages. Each transmitter message will contain four double precision words as follows:

D.P. WORD	
1	T_0, Beginning time of ramp in seconds past 0^h 1 January 1950.
2	T_F, End time of ramp in seconds past 0^h 1 January 1950.
3	DCO transmitter frequency in Hz at T_0 ($\cong$ 45 MC) [$f_{VCO} = (f_{DCO} + 20 \text{ MHZ})/3$]
4	DCO frequency rate to be applied between T_0 and T_F, Hz/sec.

3. Trailer record (standard type 66).

*※ THE TRANSMITTER REFERRED TO IN
TR32-1527 and EM 391-412 IS
THE VCO FREQUENCY ($\cong$ 22 MHZ)*

```
//       VOL=SER=JJ0097
//GO.DATA5 DD *
//
IEF236I ALLOC. FOR YZJRJMS6 GO
IEF237I 232 ALLOCATED TO PGM=*.DD
IEF237I 232 ALLOCATED TO FT05F001
IEF237I 331 ALLOCATED TO FT05F001
IEF237I 332 ALLOCATED TO FT07F001
IEF237I 331 ALLOCATED TO SYSPRINT
IEF237I 231 ALLOCATED TO SYSPRINT
IEF237I 232 ALLOCATED TO SYSPRINT
IEF237I 0C0 ALLOCATED TO FT08=001
```

File ID. Group
HEADER HEADER REC.

9.1.1

```
                    RECORD =    1  OF FILE  1
                    LENGTH =  168  BYTES
                         1          4                       101             1
   1(   00005010001   00000000013   000000000004   000000000001   000000008145   000005010001
   9(   000000000000   0000000000   000000000000   000000003000   000000000030   000000000000
  17(   000000000000   0000000000   000000000000   000000000000
  25(   000000000000
```

9.1.2   08,135   D,1108

```
                    RECORD =    2  OF FILE  1
                    LENGTH =  168  BYTES
              10   SPACES   EAFTAI   D=2400
   1(   00013010001   00001010001   000000000012   302505101210   270613310516   155622145765   556051555160
   9(   000000000000   0000000000   000000000070   000000000000   000000000000   000000000000
  17(   000000000000   0000000000   000000000000   000000000000
  25(   000000000000
```

USER LABEL GROUP
9.2.1 HEADER REC.

```
                    RECORD =    3  OF FILE  1
                    LENGTH =  168  BYTES
                11                                           103
   1(   00005010001   000000000021   000000000004   000000000000   000000000147   000005010001   000005010001
   9(   000000000000   0000000000   000000000000   000000003000   000000000000   000000000000
  17(   000000000000   0000000000   000000000000   000000000000
  25(   000000000000
```

9.2.2 BAD DESCRIPTIVE TEST

```
                    RECORD =    4  OF FILE  1
                    LENGTH =  168  BYTES
                14   CREATE   DONDD   Y,M,D   H,M=74   10,03   09,01
   1(   00017010001   000000000016   102712063112   110524231505   135522415764   155622561156   556071555061
   9(   000000000000   0000000000   000005050505   000000000000   000000000000   000000000000
  17(   000017010001
```

Same as above
△.11108

```
                    RECORD =    5  OF FILE  1
                    LENGTH =  168  BYTES
   1(   000017010001   000000000016   102712063112   110524231505   135522415764   155622561156   556070555561
   9(   055661616070   050505050505   050505050505   050505050505   050505050505
```

17(000000000000   000000000000   000000000000   000000000000   000000000000   000000000000   000000000000
25(000000000000   000000000000   000000000000   000000000000   000000000000   000000000000   000000000000

RECORD =   6 OF FILE   1
LENGTH =   168 BYTES

1(
9(
17(
25(

RECORD =   7 OF FILE   1
LENGTH =   168 BYTES

1(
9(
17(
25(

RECORD =   8 OF FILE   1
LENGTH =   168 BYTES

1(
9(
17(
25(

RECORD =   9 OF FILE   1
LENGTH =   168 BYTES

1(
9(
17(
25(

RECORD =   10 OF FILE   1
LENGTH =   168 BYTES

1(
9(
17(
25(

RECORD =   11 OF FILE   1
LENGTH =   168 BYTES